Gigabit or Bust: Next-Generation Wi-Fi

Matthew Gast

Director, Product Management

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Preparing for 802.11n to be “legacy”

- **First use of Multiple-input/Multiple-output (MIMO)**
  - Now written as #txchains x #rx chains : #streams
- **Speeds of up to 600 Mbps in the standard with 4x4:4**
  - Requires four spatial streams, and thus four radio chains per chip – only one chip vendor
  - Also requires 40 MHz channels and short GI
- **Current state of the art is 3x3:3 (450 Mbps)**
  - Only 50% greater than 3x3:2, and users want 5x (11 -> 54; 54 -> 300) before it is really interesting

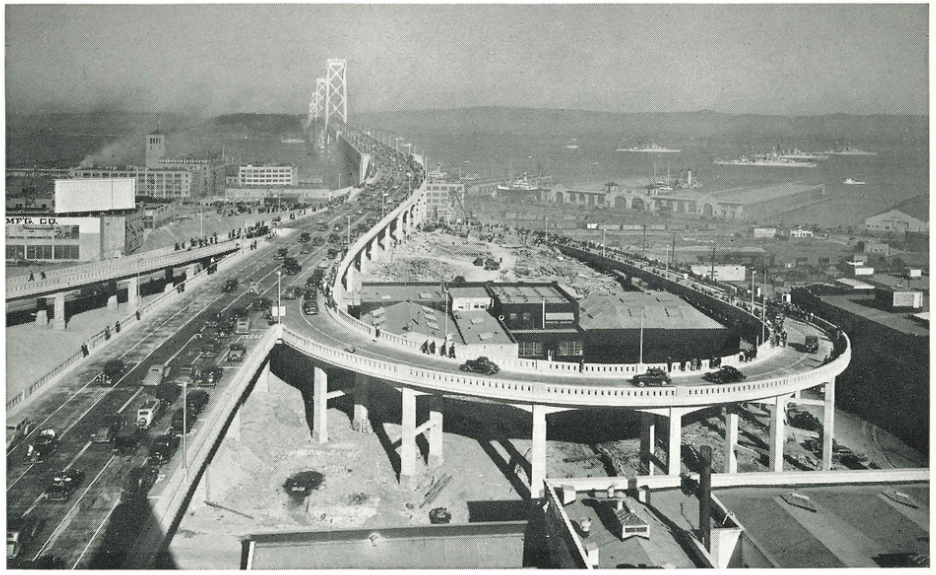
Preparing for the next burst of speed

- **11n was "High Throughput," so the next step is obviously "Very High"**
  - VHT study began as 802.11n was nearing completion
- **Two task groups formed**
  - 11ac: Gigabit at < 6 GHz: Frequency is backward-compatible with a/b/g/n
  - 11ad: Gigabit at 60 GHz: No backwards compatibility, very short range

Cheetah photo by Keven Law
http://www.flickr.com/photos/kevenlaw/2895171747/

This talk is really about 802.11ac

- Almost everybody has a 2.4/5G Wi-Fi network - planning & survey work is done
- Radio chip design well understood – same frequencies
- Users always want more speed
- This is the next big transition in Wi-Fi!



SF-Oakland Bay Bridge photo by Eric Fisher
http://www.flickr.com/photos/walkingsf/5532690501/

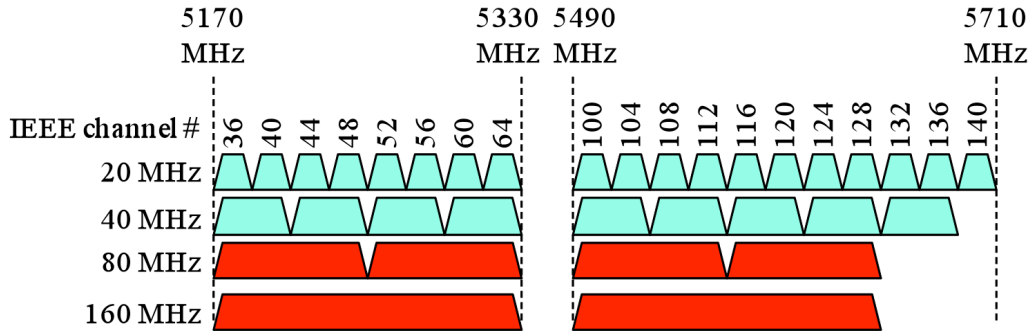
How 11ac goes faster

- **More streams: up to 8**
- **Wider channels (more on this later)**
- **More aggressive coding 1: 256-QAM vs 64-QAM**
  - Two more bits per subchannel
  - ~25 Mbps increase in data rate with 20 MHz channels
- **More aggressive coding 2: R=7/8 instead of 5/6**
- **Saving the best for last: Multi-user MIMO**

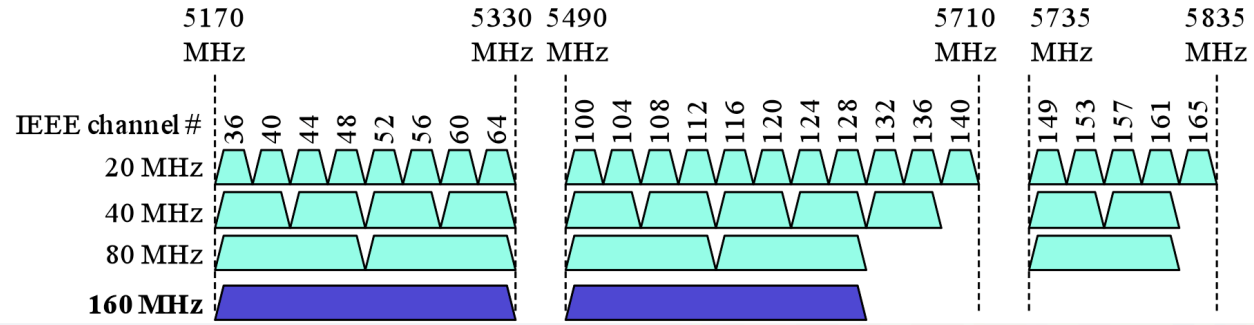
Motorway photo by Timo Kuusela
http://www.flickr.com/photos/rdvortex/2171635290/

802.11ac proposed channel width

- **80 MHz = capacity x 2, 160 MHz = x 4**
- **Planning trade-off**
  - Peak data rates use wide channels
  - Narrow channels best for total network capacity



(Europe/Japan/Global)



(USA)

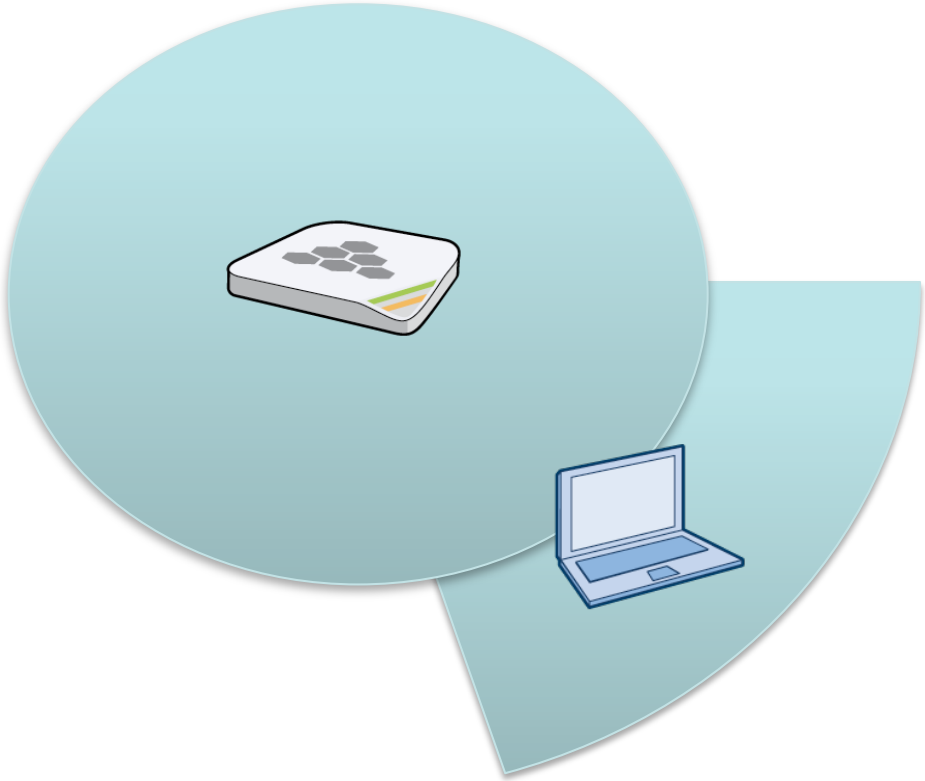
How fast is fast?

- **Today's baseline: ~300 Mbps**
  - 802.11n 2x2:2 @ 40 Mhz: 300 Mbps (w/ short GI)
  - 802.11n 3x3:3 @ 20 MHz (new MacBook Pro): 288.9 Mbps
- **Mid-range 11ac: 800 Mbps**
  - 4 streams @ 40 MHz: 800 Mbps
  - 30% better than equivalent 11n device
- **Monster peak rate 11ac: 6,933 Mbps**
  - 8 streams @ 160 MHz: 6,933 Mbps
  - Yes. You read that right: 7 Gbps
- **That is not the whole story, though!**

Sonic boom photo by Ens. John Gay, USS Constellation, USN
http://apod.nasa.gov/apod/image/0708/sonicboomplane_navy_big.jpg

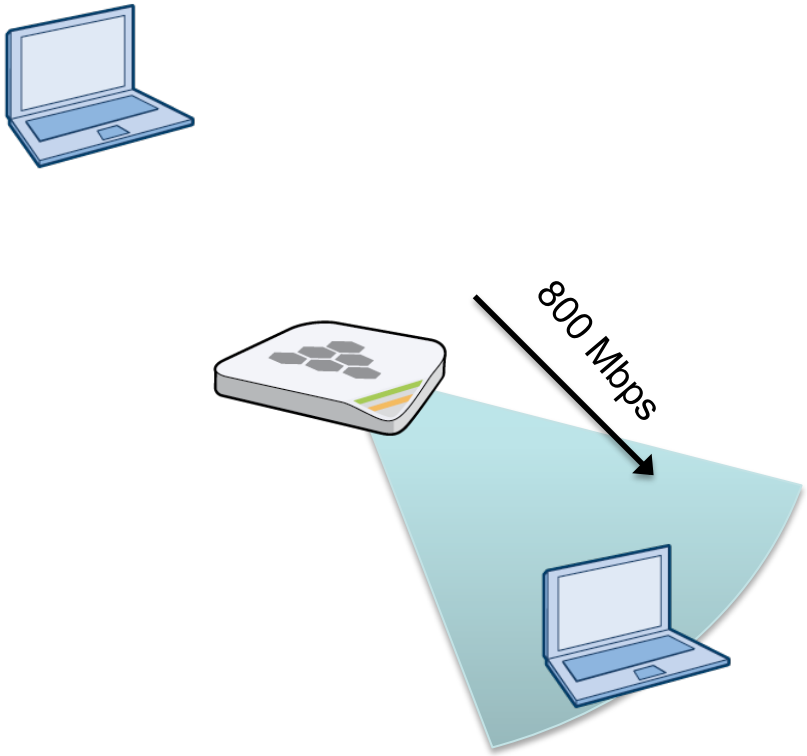
802.11 Beamforming

- **Direct energy towards a client instead of in all directions**
  - "I know half my Tx power is wasted, I just don't know which half"
- **Improves signal/noise ratio (SNR) by focusing transmissions at the client**

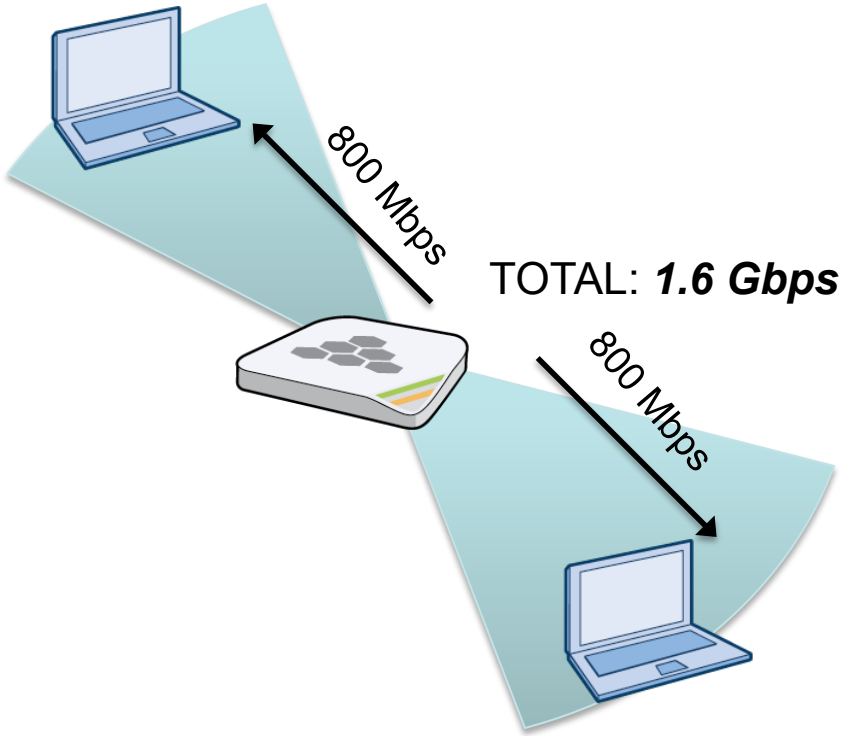


Multi-user MIMO: What is it?

- **Single-user MIMO: one transmitter**



- **Multi-user MIMO: two transmissions**



Multi-user MIMO

- **Prepare for the data flood**
- **Improved SNR raises transmission rates**
- **APs must handle multiple of the full "air rate"**
  - Forwarding, of course
  - Security: newer protocols may be required, old switch fabrics begin looking small
- **Data forwarding moves to the network edge**

Wave photo by Sergio Tudelo Romero
http://www.flickr.com/photos/ectopsyche/3461322169/

When does this happen?

- **First draft 802.11ac chips expected in 2012**
  - Consumer-grade APs can be built quickly from reference designs
  - Enterprise APs will come somewhat after that
- **Some chipmakers considering moving directly from 3x3:3 chips to 11ac**
  - 4-stream 11ac is more efficient and has higher speed
- **Wi-Fi Alliance is researching a certification program**

Clock graphic by Robbert van der Steeg
http://www.flickr.com/photos/robbie73/3387189144/

Thank you for listening!

mgast (at) aerohive (dot) com